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By: Maria P. Melchiorre Date: April 23, 2001
Maria P. Melchiorre

**IN THE UNITED STATES PATENT & TRADEMARK OFFICE**

**BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES**

| | | | |
|---|---|---|---|
| Customer No. | 026418 | | |
| Docket No. | DRAGO P-86RE / 500354.20005 | | |
| Applicant(s): | Marcello TONCELLI | | |
| Serial No.: | 09/369,570 | Group: | 1733 |
| Filed: | August 6, 1999 | Examiner: | J. Aftergut |
| For: | A PROCESS FOR THE PRODUCTION OF REINFORCED SLABS OF STONE MATERIAL | | |

Commissioner for Patents
Washington, D.C. 20231

## REPLY BRIEF

Sir

This is in response to the Examiner's answer mailed February 22, 2001 to appellant's brief on appeal filed on January 29, 2001.

At this juncture, it is desired to answer what the Examiner has indicated in paragraph 6 with respect to the issues raised as set forth on page 2 of the Examiner's Reply Brief, and issue (1), applicant's attorney was attempting to bring in the subject matter discussed 1412.02 MPEP

regarding the recapture of cancelled subject matter. Applicant's attorney was considering what is an impermissible and what is a permissible recapture of material in claims and reissue application. Specifically, 1412.03 referred to: in column 1 on page 1400-10 of revision of July 19, 1998 that "Where such claims also include some narrowing limitation not present in the claims deliberately canceled in the application, the Examiner must determine whether that narrowing limitation has a material aspect to it. If the narrowing limitation has a material aspect to it then there is no recapture. However, if the narrowing limitation is incidental, or mere verbiage, or would be inherent even if not recited (in view of the specification), then the claim should be rejected under 35 U.S.C. § 251...". It is on this basis that applicant's attorney and applicant have argued that there has been no impermissible recapture of the subject matter in the additional claims 21 to 38. Therefore, claims 21 to 38 are not properly rejected under 35 U.S.C. § 251 as being an improper recapture of broadened claimed subject matter surrendered in the application.... With the respect to the brief description of the prior art of record, applicants have no argument with the Examiner's statement as far as it has gone. However, applicants wish to submit some further information with respect to the references used by the Examiner in connection with the rejection of the claims.

Reference is made to page 7 of the Examiner's answer and in particular commencing in a lower half of the page where the Examiner quotes his reasons for allowance of the claims. Specifically, this statement for the sake of the record reads as follows: **None of the prior art of record teaches disposing a reinforcing layer between the linear reinforcing elements and a rear face of the slab of stone material** (where rear face of the stone material was substantially smooth and free from grooves or recess).

It is the applicants position that the portion referred to and stated boldly above are the reasons for allowability and the portion in parenthesis in plain type can be excluded from the reasons for allowability because as clearly emphasized and explained in the original appeal brief

be noted for the sake of the record that claims 8 to 13 are claims which were allowed in the original application and form part of the reissue patent.

As regards claims 21 to 25 they are rejected as being unpatentable for obviousness over EP 255,795 (Rigas) in view of Japanese Patent 3-247852 (Matsushita) an optionally further in view of Japanese Patent 664076 (Daiwa Wall).

The examiner's comment starts with Rigas, E.P. '795 making specific reference to the abstract and to fig.7. Any one reading this document shall appreciate that it has been probably written and filed directly by the inventor (and according to my consultant, it is enough to read the "claims" covering the last two pages to appreciate that the applicant of this reference disclosure has no idea of what a claim should be even though applicant's attorney admits that a foreign reference is only good for what it specifically teaches). It is also well known that a foreign document or foreign patent is only good for what is specifically disclosed. The specification of E.P. '795 provides general principles but no specific teachings, and is replete with theoretical considerations, but does not provide the technical information enabling the skilled worker in this field of technology to practice the alleged invention.

Apart from that it should be noted in the abstract it is only stated: *"this invention solves the problem of reinforcement of slabs with resin glass-fibers or also resin glass-clothes, which, as they are hydrophobe materials, the slabs should be completely free from dampness "*.

Thus the use of resin glass-fibers or resin glass-clothes as reinforcing materials is stated as a problem and not as a technical solution. This is the purpose, but no teaching of how to solve the problem.

For the sake of examining this patent, the cover page containing the abstract should be regarded as the cover page. Chapter Two is on page 1 as part of the introduction,

and the chapter Two appears and states in detail on page 4 of the specification. The Examiner is then referred to line 2 at the top of page 6 of the specification.

This problem allegedly is dealt with starting from "Chapter Two" of the specification. At §3 (page 6 of the specification) it is stated that *"For the reinforcement of the natural slabs we used two groups of materials:*

*a) polyester, epoxid, phenol resins and arco-xylane (?????)*

*b) resin glass clothes (emphasis added) as MAT, STUOLA and ROVING.".*

Consequently only "resin glass clothes" are contemplated and the reference to cloth does per se exclude any reference to loose filaments or fibers in a non twisted condition.

Moreover no reference is made to the ratio between the resin and the glass cloth. The Examiner's Statement that the ordinary artisan would have readily understood what amount of reinforcement to RESIN ratio to use in the final stone panels and then refers to Matsushita, Japanese Patent 3-247852.

At the paragraph 3. 1.1 (page 7) reference is made to "fine-woven resin glass cloth", at the paragraph 3.1.2 reference is made to simple glass cloth.

Turning to § 3.1.3 use is suggested of "resin glass cloth STUOIA" and at § 3.1.4 to "resin glass-cloth ROVING", which objectively and undeniably refer to different types of clothes and not to loose non twisted glass fibers, as one skilled in the art would read this disclosure.

It is worth to note that the reference to "cloth" excludes from the scope of the teaching of this prior art any non woven and consequently untwisted glass fiber.

Identical comments and the same argument can be made with respect to § 3.2 on page 8.

Turning now to "Chapter Three" which states on Page 12 of this reference and particularly to §1.2, it is undeniable that there are taken into consideration "double slabs" having polyurethane included between them namely between two slabs.

According to the specification a "resin glass-cloth" is attached to the slabs without any indication of any proportion of the resin to the glass cloth.

Moreover no mention or teaching appears of any hardening of the resin taking place afterwards, although later on it is mentioned that gravel may be thrown against the surface still "damp". However this feature also is no longer explained, apart from the possible use of the gravel for anchoring the final slab to the surface to be covered.

This reading of this reference, based on the specification and drawings, is fully different from the interpretation given by the examiner, particularly as regards the terms "mat" and "roving".

It is worth to notice that this is the main reference, whereby these discrepancies have heavy consequences on the possible combination with the secondary references.

Turning now to Matsushita, Japanese Patent 3-247852, and based on a translation, it cannot be doubted, and it is undeniable that the alleged reinforcement of thin slabs is obtained by applying to the surface thereof not only a so-called FRP layer 2 but also a reinforcing fiber layer 3, consisting of a chipped strand layer 3a made of a glass mat and a cloth 3b made of glass cloth.

The ratio 0.5-2 indicated by the examiner is the ratio between the layers 3a and 3b without any relationship with the resin. Regarding the Examiner's Statement that Japanese Patent '852 teaches that artificial stone as including half as much resin to the amount of reinforcement in the finished reinforcing layer is without any basis in the disclosure An English translation of JP 3-247852 is enclosed for ready reference.

On the basis of the amounts reported between brackets on page 5 of the translation it seems that the amount of polyester resin used for impregnating the layer 3 is far higher than 50 to 50.

Turning now to the other Japanese reference (Daiwa Wall) JP 6-64076, the English translation of which is also enclosed, in this case too the reinforcement consists of two layers one of which is a fibre reinforcing resin layer formed by reinforcing fibers interwoven into a cloth (fabric).

Thus the reading of this reference as done by the examiner is respectfully submitted not correct according to applicant's understanding.

The rejection of claims 8-13 and 26 to 38 is based on the prior Toncelli European patent 631,015 as the main reference, the above references being cited as auxiliary prior art.

Because the interpretation of auxiliary references as stated by the Examiner is not correct, also this rejection is devoid of technical basis.

This Reply Brief is submitted in triplicate and the enclosures are also being submitted in triplicate.

## CONCLUSION

The Examiner's decision should be reversed and the re-issue application with the present claims should be issued.

## REQUEST FOR ORAL HEARING

An oral hearing is respectfully requested, and our check in the amount of $270.00 is enclosed. If lost and detached, please charge to Deposit Account 50-1529.

Respectfully submitted,

REED SMITH, LLP

April 23, 2001

By: _____

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JHN/mvk
Enclosures:
Translation of JP 3-247852 and JP 6-64076
Check for $270.00 for Oral Hearing

JP 3-247,852

JAPANESE PATENT OFFICE(JP)

(12) OFFICIAL PATENT DISCLOSURE BULLETIN (A)

(11) Appl. Disol. N°.: 03247852

(43) APPLICATION DISCLOSED ON: 06th November 1991

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(21) APPLICATION N.: 0243292
(22) FILING DATE: 23rd February 1990

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## DESCRIPTION OF THE INVENTION

### 1. TITLE OF THE INVENTION

STONE PANEL

### 2. CLAIMS

[1] A stone panel, characterised in that in a stone panel reinforced by laminating FRP layers onto a surface of a thin stone, consisting of natural or artificial stone, the reinforcing fiber layers of the FRP layers are molded with a chipped strand mat and a cloth.

### 3. DETAILED DESCRIPTION OF THE INVENTION

[FIELD OF THE INVENTION]

The present invention relates to a stone panel useful in the construction of internal and external walls,

floorings of buildings, etc.. More specifically, it relates to a stone panel in which the front material is formed with a natural or artificial stone.

[PRIOR ART]

Natural or artificial stone such as marble or granite are increasingly adopted on the surfaces of floorings and onto the internal and external walls of buildings, due to their aesthetic appearance and durability. However, stone is heavy, it requiring a 20~50 mm thickness in order to provide suitable strength, manufacturing accuracy, etc.. Moreover, being subject to cracking and chipping it entails handling problems.

Furthermore, in recent times the development of a technique allowing a stone cutting into thin sections (1.0~5 mm) has become widely popular. However the stone by itself is fragile, and due to the occurring of chipping and cracking during the handling and the transport thereof, it cannot be suitably used as building material. In order to overcome this drawback, a blister material, FRP, metal plate, honeycomb core, etc. is applied onto the stone panel rear side. For instance, JP Shô63-222850 teaches the application of a FRP layer on the stone panel rear side.

[PROBLEMS TO BE SOLVED BY THE INVENTION]

However, in a stone panel in which a FRP layer is applied onto the rear surface, when a cloth is adopted as

the reinforcing fiber layer of the FRP layer the stretchability thereof is increased, whereas the bendability thereof is decreased. Moreover such technique is expensive, and it reveals unevenness.

Adopting a chipped strand mat as a reinforcing fiber layer is more cost-effective, however the bendability thereof is reduced.

More specifically, concerning the stone bending, the application of a FRP layer thereon entails a strength problem, whereas concerning the arcuation, the problem lies in the FRP following the stone, and possible panel warpings. The cloth provides excellent strength, whereas the mat, easily bending and following the stone bending, provides satisfactory arcuation. Furthermore, unevenness remaining on the cloth may cause a straining of the stone.

The present invention overcomes the hereto described drawbacks: The purpose of the present invention is to provide a stone panel that both displays strength and bendability and is cost-effective.

[MEANS TO OVERCOME THE PROBLEM]

The stone panel A according to the present invention is characterised in that it is formed by laminating reinforcing fiber layers 3 with FRP layers 2, molded with the layer of a chipped strand mat 3a, and the layer of a cloth 3b, onto the rear side surface of a thin stone 1, formed with natural or artificial stone.

[EFFECT OF THE INVENTION]

[...][1] there are the following advantages: (...penetrates; they can be utilised as lighting cover, light hardening adhesive agents can be applied therein), etc. ③ The cutting thereof is easy. ④ The stretchability ratio is comparatively near to the stone one.

The FRP layer 2 can be manufactured as follows: ① A manufacturing process in which a mat and a cloth are laminated onto the stone surface and a resin is applied thereon. ② A manufacturing process in which a pre-impregnated shaped object is laminated and hardened onto the stone panel. ③ A manufacturing process in which a FRP sheet, previously formed with a separate processing, is attached onto the surface of the stone. Among the above-mentioned manufacturing processes, certainly number ③ does not cause many panel warpings, with no hardening shrinkage subsisting in the manufactured panel. Suitable resins for the FRP layer 2 can be polyester, epoxy, acrylic resins or the like, however polyester resins are commonly adopted. Suitable fibers for the reinforcing fiber layer 3 can be glass, polypropylene, carbon fibers, or the like, however

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[1] *[PUNTO TRADUZIONI's Note:*
*In the original text some lines (probably 3-4) are missing, both in your copy and in the one filed at the Japanese Patent Office, that we subsequently downloaded. Judging from the subsequent sentence, possibly the missing lines might relate to the features and advantages of the reinforcing fiber layer 3].*

glass fibers are widely adopted.

The present invention will hereinafter be described in detail by means of specific examples thereof.

(SPECIFIC EXAMPLES)

The advantages provided by both the chipped strand mat 3a and the cloth 3b were fully exploited by the present inventors by forming the reinforcing fiber layer 3 of the FRP layer 2 with the chipped strand mat 3a made of a glass mat (230g/$m^2$) and the cloth 3b (made of a glass cloth (230g/m2)), and impregnating it with a polyester resin (1000g/$m^2$)).

[PREFERRED EMBODIMENT]

The stone panel A according to the present invention, as shown in Fig. 1, is formed by laminating the FRP layer 2 onto the rear surface of the thin stone 1 formed with natural or artificial stone. The weight ratio per unit area (g/$m^2$) of the chipped strand mat 3a to the cloth 3b is preferably set to be 0.5~2. Preferably, between the chipped strand mat 3a and the cloth 3b the former is positioned onto the surface of the stone 1.

Furthermore, the FRP is utilised as the material applied on the rear surface of the stone 1 for the following reasons: ① It is resilient (strong, although thin). ② It is permeable and dyeable. The present inventors applied a light-hardened FRP sheet (thickness=0.8 mm) onto a stone (width=400x400 mm; thickness=7 mm), by means of an adhesive

agent of the urethane type. A flooring material was obtained by polishing, cutting, bevelling the corners of the panel thus manufactured. Even after a 100-hour boiling this stone panel displayed mere 0.2 mm warpings over its 400 mm length.

[EFFECT OF THE INVENTION]

The present invention fully exploits the characteristics of the chipped strand mat and of the cloth, by virtue of the reinforcing fiber layer of the FRP layer thereof being formed with a chipped strand mat and a cloth as described, thereby being highly resilient, and also easy to bend. Furthermore, it is cost-effective as only a small cloth quantity is utilised therein.

4. BRIEF DESCRIPTION OF THE DRAWINGS

In the drawing, Fig. 1 depicts a section of an embodiment of the stone panel according to the present invention.

1 ..... Stone

2 ..... FRP layer

3 ..... Reinforcing fiber layer

3a ..... Chipped strand mat

3b ..... Cloth

A ..... Stone panel

AGENT: PATENT ATTORNEY: ISHIDA CHÔSHICHI

JP 6-64076

JAPANESE PATENT OFFICE (JP)
(12) OFFICIAL PATENT DISCLOSURE BULLETIN (A)
(11) APPL. DISCL. N.: 0664076
(43) APPLICATION DISCLOSED ON: 8th MARCH 1994

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| 17/04 | E | |
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(54) [TITLE OF THE INVENTION]

# COMPOSITE PLATE MATERIAL AND ITS MANUFACTURE

(57) [ABSTRACT]

[PURPOSE] To provide a composite plate material and a manufacture therefor which can display a sufficient shock resistance and bending strength even when the thickness of a fragile plate material is not larger than 5 mm, and improve the handling convenience and reduce the weight. [CONSTITUTION] A first fiber-reinforced resin layer 102 and a second fiber-reinforced resin layer 104 are laminated on the front or rear surface of a fragile plate material 100

such as a ceramic plate material, a thin sheet of natural stone such as marble, a tile or concrete thin sheet, etc. The first fiber-reinforced resin layer 102 is formed by impregnating with a resin (matrix resin) 6 reinforcing fibers 2 orientated in one direction, while the second fiber-reinforced resin layer 104 is formed by impregnating with the resin (matrix resin) 6 reinforcing fibers 4 interwoven into a cloth (fabric).

[CLAIMS]

[CLAIM 1] A composite plate material characterised in that it is formed by laminating a first fiber-reinforced resin layer, wherein the reinforcing fibers are impregnated with a resin, and are arranged in at least one direction onto a side of a fragile plate-shaped base, and a second fiber-reinforced resin layer, wherein the reinforcing fibers are interwoven into a cloth (fabric), and impregnated with a resin.

[CLAIM 2] A manufacturing method of a composite plate material, characterised in that: (a) a fragile plate-shaped base is prepared; (b) a reinforcing fiber sheet is formed, by adhering, by means of an adhesive layer, reinforcing fibers orientated in one direction onto a supporting sheet, made of reinforcing fibers interwoven into a cloth; (c) said reinforcing fiber sheet is positioned onto a side of said fragile base plate; (d) a resin matrix is applied onto the outer surface of said reinforcing fiber sheet, and said

supporting and reinforcing fiber sheets are subsequently impregnated with the resin matrix and hardened.

[CLAIM 3] A manufacturing method of a composite plate material characterised in that: (a) a fragile plate-shaped base is prepared; (b) a reinforcing fiber sheet is formed by adhering, by means of an adhesive layer, reinforcing fibers orientated in one direction onto a supporting sheet, composed of reinforcing fibers interwoven into a cloth; (c) after the matrix resin has been positioned onto a side of said fragile base plate, said reinforcing fiber sheet is adhered onto said base plate by facing the former to a side of said fragile base plate surface; (d) a resin matrix is applied onto the outer surface of said reinforcing fiber sheet, and said supporting and reinforcing fiber sheets are subsequently impregnated with the resin matrix and hardened.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION] The present invention relates to a composite plate material, wherein a fiber-reinforced resin layer is adhered onto the front or the rear surface of a fragile plate material such as a ceramic plate material, a thin sheet of natural stone such as marble, a tile or concrete thin sheet, etc., having a remarkable shock resistance and bending strength. Moreover, since the plate material can be very thick, the weight thereof can be

further reduced, thus being suitable for interior and exterior trims of buildings, floorings, table top boards, doors, etc.

[0002]

[PRIOR ART] In recent years, ceramic plate materials, thin sheets of natural stone such as marble, tiles or concrete thin sheets, etc. have been utilised as interior and exterior trims of buildings, flooring, table top boards, doors, etc., however such materials have a high specific weight, and furthermore are expensive. Hence, the attainment of a minimum material thickness is desirable in order to reduce the weight and to improve the handling convenience thereof, concurrently cutting the material costs, as well as the transport and working costs thereof. However, reducing the thickness of the material entails a decrease in the shock resistance thereof, and the material becomes fragile, thus requiring great care in handling.

[0003] In order to overcome those drawbacks, JP Shô 63-222850 teaches a composite plate material, wherein a FRP pre-impregnated tape, impregnated with a resin using glass fiber as reinforcing fiber, is adhered onto a 10 mm thick side of such fragile plate material.

[0004]

[PROBLEMS TO BE SOLVED BY THE INVENTION] However, tests carried out by the present inventors highlighted that, in order to provide a sufficient shock resistance, the

thickness of a composite plate material having the aforementioned taught structure should be of at least 10 mm; e.g., in case of a fragile plate material wherein the thickness is of less than 5 mm, not only its shock resistance tested insufficient, the bending strength thereof was remarkably reduced as well.

[0005] Therefore, a purpose of the present invention is that of providing a composite plate material and manufacture therefor which can display sufficient shock resistance and bending strength even when the thickness of a fragile plate material is not larger than 5 mm, and improve the handling convenience and reduce the weight.

[0006]

[MEANS TO SOLVE THE PROBLEMS] The abovementioned purpose is attained by means of the composite plate material and of the manufacture thereof according to the present invention. In short, the present invention consists of a composite plate material characterised in that a first fiber-reinforced resin layer formed impregnating with a resin reinforcing fibers arranged in at least one direction, and a second fiber-reinforced resin layer formed impregnating with a resin reinforcing fibers interwoven into a cloth, are laminated onto a side of a plate-shaped fragile base.

[0007] Preferably, such composite plate material can be manufactured according to a manufacturing process characterised in that: (a) a fragile plate-shaped base is

prepared beforehand; (b) a reinforcing fiber sheet formed by adhering, by means of an adhesive layer, reinforcing fibers orientated in one direction onto a supporting sheet, made of reinforcing fibers interwoven into a cloth; (c) said reinforcing fiber sheet is positioned onto a side of said fragile base plate; (d) a resin matrix is applied onto the outer surface of said reinforcing fiber sheet, and said supporting and reinforcing fiber sheets are subsequently impregnated with the resin matrix and hardened.

[0008] Alternatively, said composite plate material can also preferably be manufactured according to a manufacturing process characterised in that: (a) a fragile plate-shaped base is prepared beforehand; (b) a reinforcing fiber sheet is formed, by adhering, by means of an adhesive layer, reinforcing fibers orientated in one direction onto a supporting sheet, composed of reinforcing fibers interwoven into a cloth; (c) after the matrix resin has been positioned onto a side of said fragile base plate, said reinforcing fiber sheet is adhered onto said base plate by facing the former to a side of said fragile base plate surface; (d) a resin matrix is applied onto the outer surface of said reinforcing fiber sheet, and said supporting and reinforcing fiber sheets are subsequently impregnated with the resin matrix and hardened.

[0009]

[DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS]

The composite plate material and its manufacture according to the present invention will hereinafter be described in detail making reference to the annexed drawings.

[0010] The composite plate material 10 according to the present invention is formed laminating a first fiber-reinforced resin layer 102 and a second fiber-reinforced resin layer 104 on the front or rear surface of a fragile plate 100, such as a ceramic plate material, a thin sheet of natural stone such as marble, or a tile or a concrete thin sheet, and the like. The sole limitations of the thickness (T) of the plate material 100 are those inherent to the manufacturing process, e.g., even a 2-4 mm thickness can be utilised in a ceramic or marble plate material.

[0011] Moreover, the first fiber-reinforced resin layer 102 is formed impregnating with the resin (matrix resin) 6 the reinforcing fibers 2 orientated in one direction, and the second fiber-reinforced resin layer 104 is formed impregnating with resin (matrix resin) 6 the reinforcing fibers 4 interwoven into a cloth (fabric).

[0012] Preferably, carbon fibers are adopted as the reinforcing fibers 2 utilised in the abovementioned fiber-reinforced resin layer 102, however inorganic fibers like boron fibers, glass fibers, alumina fibers, silicon carbide fibers, silicon nitride fibers, etc., and organic fibers like aramid fibers, polyarylate fibers, polyethylene

fibers, polyester fibers, or metallic fibers like titanium fibers, amorphous fibers, stainless steel fibers, etc., or hybrid fibers made of a mixture thereof can be utilised as well. Furthermore, in the second fiber-reinforced resin layer 104, preferably carbon fibers, glass fibers, or organic fibers like aramid fibers, polyarylate fibers, polyethylene fibers, polyester fibers can be utilised as reinforcing fibers 4 of the cloth.

fibers 2

[0013] The matrix resin 6 that impregnates the reinforcing fiber 2 and 4 in the first and second fiber-reinforced resin layers 102 and 104 can be a common resin, e.g. thermoset matrix resins like epoxy resins, unsaturated polyethylene resins, polyurethane resins, diarylphtalate resins, phenolic resins, etc., can be utilised. Furthermore, hardening agents or other additives, e.g. additives providing bendability can be added in order to satisfy specific needs in order to obtain a hardening with a temperature preferably comprised in the range 50-200 °C, more preferably with a uniform temperature.

[0014] A preferred embodiment can be realised using an epoxy resin as matrix resin, e.g., among suitable epoxy resins there can be (1) glycidyl ether type epoxy resins (bisphenol A, F, S, type epoxy resins; novolac type epoxy resins; bromate bisphenol A type epoxy resins); (2) epoxy resins belonging to the cyclic fats group; (3) glycidyl ester type epoxy resins; (4) glycidyl amine-type epoxy

resins, tetra-glycidyl amino diphenol methane, tri glycidil-p-amino phenol epoxy resins, etc.; (5) cyclic epoxy resins made of various elements; one or more epoxy resins selected among the above-mentioned ones can be utilised; in particular, preferably bisphenol A,S,F, glycidyl amine- type epoxy resins are utilised. Moreover, amine-type hardening agents like dicyanamide (DICY), diamino diphenol sulphone (DDS), diamino diphenol methane (DDM), acidic anhydrides like hexa hydro phthalic anhydride (HHPA), methyl hexa hydro phthalic anhydride (MHHPA) can be utilised, however, more preferably hardening agents of the amine group are utilised.

[0015] Moreover, the combination ratio of reinforcing fibers 2 and 4 contained in the first and second fiber-reinforced resin layers 102 and 104 can be set according to the specific needs, however usually the weight percentage is set according to the following proportion:

reinforcing fibers : matrix resins = 20~70 : 80~30;

furthermore, the thicknesses ($T_1$) and ($T_2$) of each fiber-reinforced resin layer 102 and 104 can match the diameter of the reinforcing fibers utilised, however usually it is set within a 50~1000μm range.

[0016] In a composite plate material 10 according to the present invention thus manufactured, both the shock resistance and the bending strength thereof are remarkably

enhanced thanks to the laminating of the first fiber-reinforced resin layer 102, having the reinforcing fibers 2 orientated in one direction, and of the second fiber-reinforced resin layer 104, having the reinforcing fibers cloth 4, onto a fragile plate material 100. Thus, the thickness of the adopted fragile plate material is reduced of more than 50% compared to the aforementioned composite plate material taught in JP Shô 63-222850, wherein a FRP tape, obtained by impregnating a glass fiber (as reinforcing fibers) tape with resin, was adhered to a 10 mm thick surface of a composite plate material. Moreover, a weight increase is avoided since also the total thickness ($T_1+T_2$) of the first and second fiber-reinforced resin layers 102, 104 does not exceed 0.5~2 mm.

[0017] The composite plate material 10 manufactured according to the present invention can be formed according to several manufacturing processes; hereinafter one preferable manufacturing process thereof is disclosed.

[0018] According to the manufacture in accordance with the present invention, firstly, as shown in Fig. 2, a reinforcing fiber sheet 1, formed by adhering with an adhesive layer 6' the reinforcing fibers 2 orientated in one direction onto a supporting sheet made of reinforcing fibers 4 interwoven into a cloth, is prepared.

[0019] More specifically, as supporting sheet resin-permeable screen cloths, glass cloths or the like are

utilised. Therefore, as it will hereinafter be detailed later, said supporting sheet 4 and the reinforcing fibers 2 can be impregnated with resin, i.e. the matrix resin 6, from the side of the supporting sheet 4. The thickness of the supporting sheet 4 should be comprised within an 1~500μm range, preferably in a 5~50μm range, because the reinforcing fibers 2 should be flexible, concomitantly having a sufficient supporting strength.

[0020] In general, the adhesive agent forming the adhesive layer 6' can be any adhesive agent capable to adhere, at least temporarily, the reinforcing fibers 2 the supporting sheet 4 therebetween, however preferably an adhesive agent capable to convey, by means of the matrix 6, the reinforcing effect of the fibers to the adhesive layer as well is utilised. Accordingly, preferably a resin having a good mutual solubility with the matrix resin 6 should be utilised in the adhesive layer 6'. For instance, when using an epoxy resin as matrix resin, an epoxy-type adhesive agent is to be preferred. The thickness of the adhesive layer 6' can be selected within a 5~100μm range, preferably within a 10~30μm range, since it should temporarily adhere the reinforcing fiber 2 and the supporting sheet 4 therebetween.

[0021] The reinforcing fibers 2 are obtained by converging filaments into fiber bundles by means of a converging agent

or of a slight twisting thereof. Those bundles are lined up, and adhered, slightly scattered thereamong, onto the adhesive layer 6' by means of a downward pressure applied thereon. The reinforcing fibers 2 thus obtained, laminated in several layers by means of a twisting or converging agent and oriented in one direction, are adhered onto the supporting sheet by means of an adhesive layer 6'. Thus, the desired reinforcing fiber sheet 1 is obtained.

[0022] In this case, as shown in Fig. 3 (a), the reinforcing fiber 2 can be formed by lining up the reinforced fiber bundles 2' onto the supporting sheet 4 by means of the adhesive layer 6'. Said fiber bundles 2' are oriented in one direction and horizontally closely packed thereamong. Then, as shown in Fig. 3 (b), the lower portion of the reinforcing fiber bundles is adhered onto the supporting sheet 4[1] by means of the adhesive layer 6', by exerting a downward pressure onto the fiber bundles 2', thereby closely adhering the bundles without horizontal spacing thereamong onto the supporting sheet 4. Alternatively, as shown in Fig. 4 (a), the reinforcing fiber 2 can likewise be formed by lining up the reinforced fiber bundles 2' onto the supporting sheet 4 by means of the adhesive layer 6', but with the fiber bundles 2' oriented in one direction and horizontally loosely packed

[1] *[PUNTO TRADUZIONI'S NOTE: The original mistakenly reports the reference No. 2 ]*

thereamong, and by adhering the lower portion of the bundles 2' onto the sheet 4 by exerting a downward pressure thereon, thereby forming horizontal spacing thereamong, as shown in Fig. 4 (b).

[0023] Fiber bundles 2' wherein the opening among the comrade fibers, i.e. the comrade filaments, has been carried out or not can be utilised. The amount of pressure to be exerted onto the fiber bundles can be set at will. However, when e.g. carbon fibers are utilised as reinforcing fiber 2, in case of carbon fiber bundles in which about 12000 filaments having a 5~15μm diameter are converged, the bundles will be pressed in order to attain an approximate horizontal width of 5 mm.

[0024] As shown in Fig. 5, a reinforcing fiber sheet 1 thus made is adhered onto a front or rear side of the fragile plate material 100. Said plate material 100 has a primer 6'', made of the same resin type of the matrix resin 6, applied thereon. The sheet 1 should face the fragile plate material 100 at the side provided with the reinforcing fibers 2. Preferably, a primer 6'' could be applied onto the fragile plate material 100 surface prior to the positioning of the reinforcing fiber sheet 1.

[0025] Furthermore, the matrix resin 6 is applied by means of a spreading roller or the like at the supporting sheet 4 side, positioned onto the outer side of the sheet 1 lying onto the fragile plate material 100. Thus, the matrix resin

6, seeps through the supporting sheet 4, until reaching the reinforcing fiber 2. Then, always maintaining the resin-impregnated reinforcing fiber sheet 1 pressed onto the fragile plate material 100 with suitable means, the matrix resin 6 is thermally hardened.

[0026] Thus, the composite plate material 100 is manufactured as shown in Fig. 1, laminating therebetween the first fiber-reinforced resin layer 102, formed impregnating with the resin 6 the reinforcing fibers 2 oriented in one direction, and the second fiber-reinforced resin layer 104, formed impregnating with the resin 6 the reinforcing fibers interwoven into a cloth, onto a side of the fragile plate material 100.

[0027] The instance in which an individual reinforcing fiber sheet 1 is laminated onto a fragile plate material has been disclosed in the preceding embodiment, however, several sheets can be laminated in order to satisfy specific needs. In this instance the laminated reinforcing fiber sheets 1 can be oriented so that the respective directions of the reinforcing fibers 2 oriented in one direction differ thereamong. Moreover, although in the present embodiment the reinforcing fiber sheet 1 was attached to the fragile plate material 100 from the side of the reinforcing fiber 2 oriented in one direction, the reinforcing fiber sheet 1 could also be attached to the fragile plate material 100 from the side of the supporting

sheet 4.

[0028] Furthermore, according to another embodiment of the present invention, initially the matrix resin 6 is applied onto the reinforcing fibers 2 oriented in one direction or onto the supporting sheet 4 of the reinforcing fiber sheet 1, by means of a suitable application device such as a spreading roller, a brush, a sprayer or the like. Then, a single, or a suitable number of, reinforcing fiber sheet 1 is attached and laminated onto the fragile plate material, which, in order to satisfy specific needs, can be provided with a primer, from the side thereof where said resin has been applied. Subsequently, the matrix resin can also be applied onto the outer surface of the reinforcing fiber sheet 1 with a hand roller or the like, and the impregnation of the sheet 1 can take place.

[0029] In the present invention, heating means can advantageously be made superfluous when a resin hardening at room temperature is utilised as matrix resin, e.g., an epoxy resin hardened at room temperature by adjusting the rate of a hardening agent.

[0030] In comparison with the known manufacture of composite plate material carried out by laminating pre-impregnated layers, the above-disclosed manufacture of a composite plate material 10 according to the present invention advantageously allows simpler pressurising and heating means of the fragile plate material 100, thereby

easing the entire process. Moreover, the reinforcing fiber sheet 1 can be fittingly applied onto the contour of the fragile plate material 100 even when the surface of the latter is curved, because it has been applied prior to the impregnation with the matrix resin 6. Hence, a good machinability, as well as a flawless positioning thereof are provided.

[0031] Hereinafter, a more detailed description of the composite plate material 10 according to the present invention will be provided.

[0032] Embodiment example 1.

A ceramic plate (600x600 mm, 4 mm thick) is utilised as fragile plate material 100, the related reinforcing fiber sheet 1 being implemented as follows:

[0033] A 30µ wide glass cloth (product name: KS-1020, manufactured by Kanebô Co.ltd.) is utilised as the supporting sheet 4, onto which a mere $20g/m^2$ of epoxy resin is applied as adhesive layer 6'.

[0034] As reinforcing fiber 2, PAN type 7.0µm diameter carbon fibers (product name T-300, manufactured by Tôre Co.ltd.) are utilised. Said carbon fibers are bundled together with 12000 filaments per bundle, and arranged onto the aforementioned supporting sheet 4 with a 4.6 mm spacing, then the reinforcing fiber bundles 2' are pressed downwards until a 5 mm horizontal width thereof is

attained, and the reinforcing fibers 2 are arranged onto the supporting sheet 4, equally spaced thereamong.

[0035] A primer is applied onto a surface of the aforementioned fragile plate material 100, then the aforementioned reinforcing fiber sheet 1 is attached onto said surface, facing the material 100 with the carbon fibers 2 of the sheet 1. Moreover, the matrix resin 6 is applied at the side the supporting sheet 4 by means of a spreading roller, impregnating it until reaching the reinforcing fibers 2. As matrix resin 6 a type of epoxy resin hardening at room temperature (product name: FR resin, manufactured by Tônen Co.ltd) is utilised.

[0036] After 24 hours under the abovedisclosed conditions the matrix resin 6 is hardened. The reinforcing fibers/matrix resin ratios in the first and second fiber-reinforced resin layers 102, 104 of the composite plate material 100 thus made, expressed as percentage by weight, are the following:

in the first fiber-reinforced resin layer 102,

reinforcing fibers 40%, matrix resin 60%;

in the second fiber-reinforced resin layer 104,

reinforcing fibers 30%, matrix resin 70%;

furthermore, the thicknesses of the first and second fiber-reinforced resin layers 102, 104 are $T_1$=320μm and $T_2$=60μm, respectively.

[0037] A bending test was carried out on said composite

plate material 10 by the present inventors. Such composite plate material 10 displayed a 2.4 kgf/mm$^2$ bending strength, i.e. 6.7 times greater than the bending strength of the 4 mm wide ceramic plate 100 (0.36 kgf/mm$^2$). Moreover, with regard to the shock resistance of the composite material, the non-reinforced ceramic plate broke, whereas the composite plate material of this embodiment, formed according to the present invention, did not.

[0038] Furthermore, the present inventors carried out a bending test of the present embodiment, slicing a 15x20 mm testing specimen of the composite plate material 10, providing the reinforcing fiber 2 longitudinally oriented in one direction to be lined up; said testing specimen was positioned onto two supporting rods having a 2 mm radius spaced of 100 mm therebetween, and a 5 mm radius head was pushed onto the median portion of said testing specimens by means of a 3.5 mm thickness Teflon plate, and pressed thereon with a 2 mm/min head speed.

[0039] Further, the present inventors carried out a shock resistance test onto the composite plate material 10, positioning it onto two supporting rods having a 2 mm radius and spaced of 100 mm therebetween, located longitudinally to the reinforcing fibers 2 oriented in one direction, and dropping a 500g steel ball from a 300 mm height onto the median section of said testing specimen.

[0040] Comparative example 1

The glass cloth utilised in the previous embodiment was attached onto a surface of the same ceramic plate material 100 of the previous embodiment, and a composite plate material was manufactured, impregnating it with the same epoxy resin of the room temperature hardening type already utilised in the previous embodiment. After 24 hours under the above conditions the matrix resin 6 was hardened.

[0041] The reinforcing fiber cloth/matrix resin ratio in the fiber-reinforced resin layer of the composite plate material thus manufactured, expressed as percentage by weight, is the following:

reinforcing fibers 40%, matrix resin 60%;

furthermore, the thickness of the fiber-reinforced composite resin layer is of 320μm.

[0042] Bending strength and shock resistance tests were also carried out by the present inventors on such composite plate material, adopting the same testing method of the previous embodiment. This composite plate material did not break during the shock resistance test, however, with regard to the bending strength test, it displayed only a 1.0 $kgf/mm^2$ bending strength , 2.8 times that of the single ceramic plate material (0.36 $kgf/mm^2$), showing a reinforcing effect lower than the one displayed in the previous embodiment.

[0043] Comparative example 2

The same carbon fiber bundles utilised in the embodiment 1

were positioned, with a 4.6 mm spacing thereamong, onto the same ceramic plate material 100 of the previous embodiment, and a downward pressure was exerted onto each bundle until a 5 mm horizontal width and an equal arrangement thereamong was attained. Then the composite plate material was formed, impregnating the carbon fibers with the same epoxy resin of a type hardening at room temperature utilised in the previous embodiment. After 24 hours under the above conditions the matrix resin 6 was hardened.

[0044] The reinforcing fiber/matrix resin ratio in the fiber-reinforced resin layer of the composite plate material thus manufactured, expressed as percentage by weight, is the following:

reinforcing fibers 40%, matrix resin 60%;

furthermore, the thickness of the fiber-reinforced composite resin layer is of 320μm.

[0045] Bending strength and shock resistance tests were also carried out by the present inventors on this composite plate material, adopting the same testing method of the previous embodiment. With regard to the bending strength test, this composite plate material displayed a (2.5 $kgf/mm^2$) bending strength , 6.9 times that of the non-reinforced ceramic plate material (0.36 $kgf/mm^2$), but as it broke during the shock resistance test, it did not provide a satisfactory reinforcing effect.

[0046]

[EFFECT OF THE PRESENT INVENTION] The composed plate material according to the present invention manufactured as hereto disclosed can display a sufficient shock resistance and bending strength even when the thickness of a fragile plate material is not larger than 5 mm, and improves the handling convenience and reduces the weight. Moreover, by virtue of the manufacture of the composite plate material according to the present invention, the heating and pressurising means are simplified, thereby allowing a highly versatile manufacture, that can easily be implemented even in case of curved fragile plate materials.

[BRIEF EXPLANATION OF THE DRAWINGS]

[Fig. 1] is a sectional view of the structure of the composite plate material of an embodiment according to the present invention.

[Fig. 2] is a sectional view of the structure of the reinforcing fiber sheet utilised in the manufacture of the composite plate material according to the present invention.

[Fig. 3] is a sectional view of the structure of the reinforcing fiber sheet, illustrating the manufacture thereof.

[Fig. 4] is a sectional view of the structure of the reinforcing fiber sheet, illustrating the manufacture thereof.

[Fig. 5] is a sectional view of the structure of the

composite plate material according to the present invention, illustrating the manufacture thereof.

[REFERENCE NUMBERS]

1 ..... Reinforcing fiber sheet

2 ..... Reinforcing fibers oriented in one direction;

4 ..... Reinforcing fiber cloth (supporting sheet);

6 ..... Matrix resin;

6' ..... Adhesive layer;

6" ..... Primer;

100 ..... Fragile plate material;

102 ..... First fiber-reinforced resin layer;

104 Second fiber-reinforced resin layer;